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DEFENSE SYSTEMS MANAGEMENT COLLEGE
FORT BELVOIR, VIRGINIA

A STUDY OF THE RELATIONSHIP BETWEEN INITIAL PRODUCTION TEST ARTICLES USED IN A SYSTEM DEVELOPMENT PROGRAM AND THE SUCCESS OF THAT PROGRAM

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With the gratefully acknowledged assistance of the staff of the David D. Acker Library at Defense Systems Management College (DSMC), a search of related literature was conducted for this report.

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ABSTRACT

This research effort has as its principal objective, the collection of data to determine if there is a relationship between the number of Engineering and Manufacturing Development (EMD) test articles used and the managerial success of that program within the EMD phase of a major system acquisition. Managerial success is largely measured in terms of a low schedule overrun during EMD. The research approach taken also gathered other acquisition related data discussed herein. This allowed comment on the current "track record" of DoD cost and schedule overruns during EMD, and some interesting data on six other variables that could affect program success. The conclusion is that there is a positive correlation between the number of test articles and program success. However, these conclusions may have been impacted by the nuances of the DoD Low Rate Initial Production (LRIP) process and the basic design of this study.

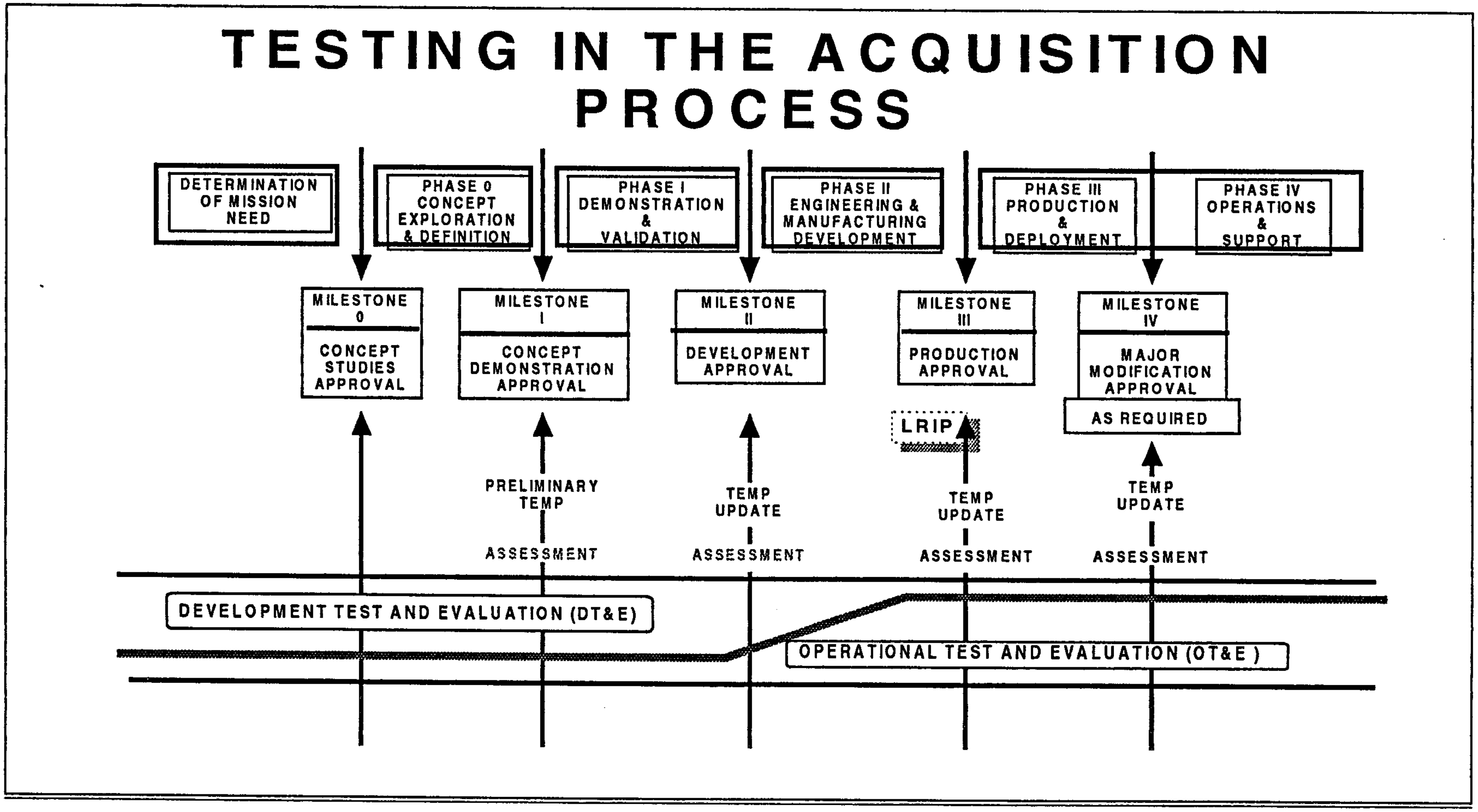

FIGURE 1. Testing in the Acquisition Process

CHAPTER 1
INTRODUCTION

Background

For major acquisition programs which include a Low Rate Initial Production (LRIP) phase, the Director of Operational Test and Evaluation (DOT&E) is responsible for approving the number of LRIP test articles required for Initial Operational Test and Evaluation (IOT&E).[1] Since 1991, Congressional Law requires the DOT&E to specify at Milestone II, the number of test articles required for this test.[2] The determination of LRIP test quantities is a difficult trade-off among several factors, and the office of the DOT&E desired to know if there was historical data that would help in making this important decision. Therefore, they requested the Defense Systems Management College (DSMC) to study if there is a relationship between the number of test articles used in Engineering and Manufacturing Development (EMD), including IOT&E, and the success of that program. Indications were factual references or metrics relating to the subject were non-existent.[3]

Overview

The research approach selected was an *ex post facto* casual-comparative effort whose hypothesis was:

> *The success of a weapon system development program is directly related to the Initial Production Test Articles used in the system EMD Phase, including the IOT&E test.*

An immediate concern was for defining the terms to be used within the study. This was necessary because many of the parameters vital to the study were known to have differing interpretations throughout the Department of Defense (DoD) acquisition organization. Appendix A lists the definitions used within this study.

For convenience, the term LRIP is used throughout this study, and is synonymous with the term Initial Production Articles, except for the type of funds used to procure the test articles. In this study the term "LRIP test quantity" is used to reflect all systems procured during EMD with Research, Development, Test and Evaluation (RDT&E) funds. This is the quantity of Initial Production Articles, less those bought with procurement funds. The reason for this distinction is the presumption the RDT&E funded items are those used for testing. Chapter 6 contains details regarding this distinction.

The LRIP phase of a program occurs during the EMD phase of a program; that is, between Milestones (M/S) II and III, (see Figure 1). The objectives of the LRIP phase are specified by statute to be:

....the production of the system in the minimum quantity necessary-
(1) to provide production-configured or representative articles for operation-

al tests pursuant to section 2399 of this title; (2) to establish an initial production base for the system; and (3) to permit an orderly increase in the production rate for the system sufficient to lead to full-rate production upon the successful completion of operational testing.[4]

All data used within this report are unclassified.

It is important to recognize that our evaluation scheme is a measure of program management success in terms of schedule slip rather than eventual weapon system success. There was no attempt to survey the effectiveness of the systems in their operational roles. Also, we did not evaluate the performance (effectiveness and suitability) of these programs in EMD although that would be an excellent additional study.

The subsequent chapters of this report are organized as follows: Chapter 2 discusses the scope of the literature search conducted, and indicates most prior research in this general area supports the findings of this research. Chapter 3 discusses the approach taken and describes the fortuitous opportunity presented to conduct a pilot study. Chapter 4 describes the limitations and assumptions implicit in this research. Chapter 5 is an analysis of this effort, limited to the degree possible to facts that emerge from the database. Chapter 6 is a discussion of opinions resulting from one viewpoint of the facts contained in the data bank. Considerable important data is also contained within the remaining areas of this report.

CHAPTER 2
REVIEW OF RELATED LITERATURE

Discussion

The primary sources used for this report were the Defense Technical Information Center (DTIC), Research on Ongoing Acquisition Research (ROAR),[5] the library research database, and the Industry Field Trip database.[6] We also inquired by corporate author, and reviewed the master's thesis written at the Naval Postgraduate School. The RAND Corporation reports were also very helpful. Of course, the Department of Defense (DoD) Directives and other Government guidance documents were utilized. Reports reviewed are listed within the references and bibliography. Some of the prior reports most germane and useful are discussed next.

Related References

Drezner's, *The Nature and Role of Prototyping in Weapon System Development,* provides us with an excellent definition of a prototype.[7] Fortuitously, his definition of prototype is exactly what an initial production article, as used in this report, is not. Therefore, there is a clean interface between these terms frequently used interchangeably, and therefore erroneously. Drezner and Smith's *An Analysis of Weapon System Acquisition Schedules*[8] reviewed the time it took to develop weapon systems over the decades of the 1950's, 60's, 70's and 80's. Two of their findings, namely that schedule estimates are not given the critical evaluation that cost estimates are given, and that there is no relationship between the time a program spends in the Demonstration/Validation (Dem/Val) phase and a reduced schedule slip, agree with our findings. A third finding, removing the effects of external factors reduces program length by a substantial amount, is intuitively agreed with. However, our study excluded any consideration of extra-program influences.

Rich and Dews' *Improving the Military Acquisition Process,*[9] contains a finding that is exactly opposite to our own. It states for programs in the 1960's, cost overruns approximated 45 percent, schedule overruns 15 percent and performance shortfalls 5 percent. "These findings support the conventional wisdom that when acquisition problems arise cost is the constant most easily relaxed and schedule is next, whereas, performance goals are adhered to most closely."

Such was the case in the 1960's. However, in the 1980's, affordability was added to the criteria for evaluating program success, along with cost, schedule and performance. Most recently, program requirements generation, which affects performance, is under review. Our own research on more recent programs indicates more programs were better able to control their cost overruns than their schedule overruns. This reversal of priorities between cost importance and schedule importance is considered an important comparative research finding.

Drezner, et al.,[10] in a 1993 study of 128 weapon system programs that were three or more years into the Engineering and Manufacturing Development (EMD) phase concluded, "The weighted average cost growth of Development Estimate baseline programs, (Milestone (M/S) II) ... as of December 1990 is 20 percent." Our own study started at the same point but continued through all of EMD concluding with M/S III actual cost data. When you consider that the average duration of the EMD phase for major programs is 7.4 years,[11] and a large degree of the cost overrun presumably occurs toward the end of EMD, Drezner's figure is remarkably close to our own higher figures, for the greater length of time.

A recent Naval Postgraduate School master's thesis[12] drew the conclusion that the majority of problems which occurred during IOT&E were directly related to test resource issues, and recommended sufficient test articles be produced and available well before the operational test was supposed to start. An earlier study performed by the Air Force Operational Test and Evaluation Center in 1991[13] concluded "it is obvious that the test articles themselves have posed the greatest proportion of [test] limitations." Our research would support these earlier independent studies.

Other studies, mentioned briefly here, comment on requirements generation and the program risk evaluation process, indicating both should be reviewed. Wiles[14] indicates the requirements generation and management process led to unrealistic operational requirements. Earlier, David Packard[15] stated all to often, requirements for new weapon systems have been overstated. Commenting on the Advanced Medium Range Air to Air Missile program's spotted history, Mayer's[16] comments "...the chief cause of Advanced Medium Range Air to Air Missile's (AMRAAM's) woes is that managers vastly over sold the program in terms of cost and schedule."

Glennan, et al.[17] reviewed risk evaluation on seven acquisition programs to determine how risk was identified and managed. He found that in three of the programs having the most difficulty, "For a variety of reasons, top-level management oversight in the Air Force and DoD discounted lower level assessments of the level of risk." Finally, the DoD Inspector General[18] in a recent Audit Report found in seven recent major acquisition programs, all entered Low Rate Initial Production (LRIP) prematurely and LRIP acquisition strategies did not effectively limit production quantities before M/S III.

Summary of Literature Reviewed

Approximately 600 titles were extracted from the Defense Technical Information Center (DTIC) and other Acker Library research reference databases. An estimated 100 bibliographies were ordered, and approximately 50 reports were scanned or read in support of this research effort. With the exception of the dis-similar findings discussed previously, the great majority of prior research findings were either very closely supportive, or generally supportive of the findings of this research.

CHAPTER 3
METHODOLOGY

Concept and Approach

An underlying concept to this study was to use only official data available to Department of Defense (DoD) principals and staff at the Defense Acquisition Board (DAB) Milestone (M/S) II and III meetings. The rationale was acquisition decisions were based largely on this data, whether it was complete or incomplete, clear or hazy, right or wrong, with regard to estimates stated. We therefore limited our data sources to the "Blue Books" used at DAB M/S meetings, and the Selected Acquisition Report (SAR) for the year the program conducted its M/S III DAB meeting. Blue Books are summary plans and data compiled for the use of DAB principals and staff assistants immediately prior to M/S meetings.

The program's planned activities and expenditures were given in M/S II DAB information. The M/S III DAB information provided us with actual activities and costs incurred during Engineering and Manufacturing Development (EMD). We were particularly interested in the planned and actual costs for EMD, and the planned and actual schedule. The DAB M/S II and M/S III cost data, as well as the SAR cost data, were adjusted for inflation as necessary to express them in the same fiscal year dollars.[19]

Forty-one weapon system programs were originally considered as the study population. A screening criteria (Appendix B) developed prior to data collection produced the study sample of twenty-four programs. Table 1 depicts the twenty-four programs studied for this report.

TABLE 1. The Twenty-Four Programs Researched

CV HELO (SH-60F)	ALCM	MK 50 Torpedo (ALWT)
MK 48 ADCAP	Navstar GPS/U.E.	FAADS LOS-F-H (ADATS)
Avenger (Ped MT Stinger)	LANTIRN (Nav & Tgt)	AMRAAM
ACM	ATACMS	B-1B Lancer (ALQ-161)
OH-58D/AHIP	TTC-39 (TRI-TAC Switch)	JTIDS (Class 2 terminals)
Trident II msl (D-5)	HARM	ASPJ (ALQ-165)
AV-8B (Harrier II)	PLS (FHTV) (NDI)	Maverick AGM-65D (IIR)
ASAT (AF)	SGT YORK gun (DIVAD)	Tomahawk (TASM & TLAM-C)

Pilot Study Conducted

The Defense Systems Management College (DSMC) was requested to participate in the quick reaction study of electronic systems acquisition cited in reference 14. At that point in time, we had just completed the concept and approach to be used in this study, and data collection was just beginning. Since the four major Command, Control, Communication and Intelligence (C^3I) systems and electronic warfare (EW) systems of interest to Dr. Wiles were among our study sample, and since his study required completion in a short ninety-days, we used this opportunity to pilot the data collection and analyses planned for the entire twenty-four programs. This pilot effort supported our planned study design, and our contribution to the Wiles-led study effort has been published.[20]

Database Description

Central to the analysis and conclusions of this study is the definition of success. This is detailed in Table 2. Only the cost and schedule success criteria are covered in this study. Performance success will be assessed in a follow-on effort. A scoring concept was devised to classify the programs and process the results as follows:

Score	*Classification of Program*
5	Very Successful
4	Successful
3	Fairly Successful
2	Marginally Successful
1	Not Successful

TABLE 2. Definition of the Success of a Program

For purposes of this research study, the success of a DoD acquisition program will be categorized in one of five ways. Either the program is Very Successful, Successful, Fairly Successful, Marginally Successful, or Not Successful. The subjective description of these categories is shown below. For this report, only the portion of the definition relating to cost or schedule overruns apply. The remainder of the definitions apply to the proposed follow-on effort.

Very Successful (Score of 5)

There are few if any, system shortcomings. The M/S II program budget and program schedule were essentially adhered to.

The DOT&E M/S III Beyond LRIP report was positive. The Service IOT&E/OPEVAL report was positive, namely effective and suitable without caveat. (If not suitable, the deficiencies could be corrected without major impact - i.e., no SAR breach)

Successful (Score of 4)

The ADM from M/S II and MS/III DAB's was straightforward. There were system shortcomings. The M/S II program budget and schedule were slipped, but not by more than 30% in cost and 12 months in schedule.

The DOT&E M/S III Beyond LRIP report was positive. The Service IOT&E/OPEVAL report was positive. The overall evaluation was effective, and suitable with perhaps a few marginally suitable parameters.

TABLE 2 (CONT)

Fairly Successful (Score of 3)

The ADM from the M/S II and M/S III DAB's contained problem statements. The program shortcomings were listed, a few could be critical. The M/S II program budget and schedule had to be revised, but is within 45% of the M/S II budget and no more than 18 months behind the M/S II schedule.

The DOT&E M/S III Beyond LRIP report contained a few negative comments. The Service IOT&E/OPEVAL report could be marginally effective and marginally suitable.

Marginally Successful (Score of 2)

The ADM's from the M/SII and M/S III DAB's indicated major performance and suitability problems existed. The program probably would be canceled on the basis of performance to date, but other external factors are being considered. The M/S II program budget and schedule was revised more than once, and is now up to 60% overrun in cost and two years behind the original schedule.

The exit criteria of the M/S II ADM was not completely met. An outcome of the M/S III DAB will be to delay entry into full rate production.

The DOT&E M/S III Beyond LRIP reported marginally effective and/or marginally suitable. The Service IOT&E/OPEVAL recommended, at best, the system was potentially effective and potentially suitable.

Not Successful (Score of 1)

The ADM from the M/S II DAB reluctantly approved the continuation of the program into EMD, or held the program in the Dem/Val phase. The M/S II budget is over 60% overrun, and the program is more than 2 years behind schedule. A DOT&E Beyond LRIP report will say not effective and not suitable. This category would also include programs that have in fact been terminated.

For programs that have not had their M/S III DAB review as yet, their success will be judged on the general approach discussed herein, and on the available official documentation.

Also of importance were other variables affecting program success, and for which data were collected. The initial list of variables affecting success is shown at Appendix C, and the six selected for data collection are shown in Table 3. Appendix D lists the schedule success rating and the cost success rating for each program. The difference in the cost and the success rating for each program is an interesting study outcome. A taxonomy of weapon system types was created for use within the study and consists of:

AIC:	Aircraft
Veh:	Vehicle
Elec -EW-A:	Electronic-Electronic Warfare-Airborne
Elec-CNR-A:	Electronic-Comm/Nav/Radar-Airborne
Elec-CNR-G:	Electronic-Comm/Nav/Radar-Ground
Mis/Mu-A:	Missile/Munition-Airborne
Mis/Mu-G:	Missile/Munition-Ground

The entire data collected for the twenty-four programs are shown in Appendix E. Forty-seven data elements or operands are listed for each program, along with their respective definition.

TABLE 3. Other Variables Affecting Program Success

Complexity of technical arrangements:
Degree of risk identified at M/S II
Use of competition during Dem/Val phase
Use of competition during EMD phase
Complexity of business arrangements:
Type of contract
Number of associate contractors
Joint program

CHAPTER 4
LIMITATIONS OF STUDY AND ASSUMPTIONS

Limitations

The data for this study were restricted to that contained within the Blue Books prepared for the Defense Acquisition Board (DAB) Milestone (M/S) II and III meetings, and the program's annual Selected Acquisition Report (SAR) for the year in which the M/S III DAB was held. This was an early deliberate design decision. The rationale was we wanted to use only the data available to the decision makers at the time the decision was made.

In some instances, the data within the Blue Books were incomplete and in some cases the type of data contained within the Blue Books varied between programs. This is not considered unusual given the time elapsed since some of the programs had their DAB meetings and the dynamics of the process.

Performance (effectiveness and suitability) was not evaluated. The primary source document for this parameter would not be the Blue Books, but rather the Service Initial Operational Test and Evaluation (IOT&E) report, and/or the DOT&E "Beyond [Low Rate Initial Production] LRIP" report. These reports for the twenty-four programs reviewed could be added to the data as a follow-on task.

By definition, this study concerns itself with the Engineering and Manufacturing Development (EMD) phase exclusively, since that is where LRIP resides.

External influences on the program were not considered. It is recognized that Congressional requirements and political and other interests can and do have a significant effect on program success. This is particularly true during the EMD phase, but would not be primarily recorded in the Blue Books.

Program concurrency - the overlapping of program development and program production phases - is a topic of current concern. This study generated little data that is relevant to concurrency, although again, program concurrency intuitively would have a major impact on program EMD success.

The degree to which software must be developed for a system is another variable which would affect program success. We had planned to include this as a variable, but discovered that the Blue Books contained very little data in this regard.

In general, the level of detail regarding programs was limited to that contained within the Blue Books. For example, we could determine the number of LRIP articles procured with Research, Development, Test and Evaluation (RDT&E) funds, and presumably used for all types of testing within EMD. We could not, however, determine the number of

LRIP articles used specifically for the IOT&E test. Even if we could, the Department of Defense (DoD) Directives require the IOT&E test article to be production representative. The data did not allow us to determine how production representative the test articles actually were.

Assumptions

The validity of this study depended greatly on how important the data contained within the Blue Books was to the actual decisions made at DAB meetings. It was assumed the Blue Book process evolved and presented, in executive summary form, information central and vital to the decision process.

Another major tenet that affected the results of this study was test articles funded by RDT&E. "Development and preproduction prototypes (RDT&E financed) will be used for IOT&E."[21] The Blue Book and SAR allowed us to determine the number of LRIP units that were RDT&E funded, and this number became the number used within this study.

Lastly, it was assumed that program managers and other acquisition executives adhered to the DoD Directives governing LRIP and other aspects of systems acquisition.

TABLE 4. Results/Findings/Analysis

A. LRIP

1. The more LRIP test quantity articles in a program, as a % of total production, the less schedule slippage there is in EMD. (Col 6, Col 20).

2. Programs that use more than 3% LRIP test quantity articles, as a % of total production, tend to be more successful in controlling schedule overruns. (Col 13, Col 20).

3. An average of 1.8% of the total planned production quantity was acquired by RDT&E funds and presumably used for testing during EMD. (Col 16, Col 19).

4. An average of 28% of the total LRIP quantity was acquired with RDT&E funds and presumably used for testing during EMD. (Col 16, Col 18).

B. GENERAL

5. The acquisition history of 24 DoD programs show an average cost overrun in the EMD phase of the programs to be 45%, and the schedule overrun to be 63%. (Col 6, Col 10).

6. The average cost overruns of 18 programs was 20% and the average schedule overrun was 32%. (Cols 6, 10).

7. Comparisons:

# of Programs	Cost O/R	Schedule O/R
24	45%	63%
18	20%	32%

8. In most weapon systems categories, (except A/C), the time overrun was greater than, or equal to, the cost overrun. (Col 6, Col 10).

C. OTHER VARIABLES

9. Programs that used competition in Dem/Val had lower Schedule Program Success than programs that did not use competition. (Col 13, Col 31).

10. The use of competition during EMD decreases the Schedule Success of the program. (Col 13, Col 32).

11. Joint programs have had significantly lower Schedule Success. (Col 13, Col 24).

12. There is no correlation between M/S II assessment of risk and program Schedule Success. (Col 13, Col 29).

13. Ten of twenty-four programs had no risk estimate in the DAB data analyzed. (Col 29).

14. No programs were rated high risk. (not permitted in EMD). (Col 29).

15. Only one program indicated Software Lines of Code, an accepted metric of S/W risk. (Col 28).

16. Programs with only one or no Associate Contractor had the most Schedule Success. (Col 13, Col 34).

17. CPAF contracts had the least Schedule Success. (Col 13, Col 33).

D. WEAPON SYSTEM CATEGORIES

18. Airborne Electronic/EW systems had the highest cost and schedule overruns of any group (Col 6, 10). The ALQ-161 cost overrun is believed to be artificially constrained.

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CHAPTER 5
ANALYSIS

Primary Findings

Table 4 lists the primary eighteen findings of this study. The columnar notation shown with each finding indicates the column of the database, Appendix E, used to derive the finding. Most findings are discussed in greater detail later in this chapter, and in Chapter 6. Also, several findings are illustrated in the figures used herein.

General

The prime objective of the study was to determine the relationship, if any, between the number of test articles used in Engineering and Manufacturing Development (EMD), including Initial Operational Test and Evaluation (IOT&E), and the success of that program when measured in cost and schedule overruns during EMD. However, the design of the study allowed for additional data to be easily collected, and derivative findings identified. One derivative, the overall performance of the twenty-four programs is shown in Figure 2 which indicates the results of the planned and actual EMD cost and schedule data for the twenty-four programs. This is the ratio of the actual EMD results to the planned figures for cost and schedule. A program that came in essentially on cost and on schedule, would have a ratio of 1:1 for both cost and schedule. Eighteen of the twenty-four programs came in under 100 percent cost and schedule overrun, (ratios of 2:1 in each area). For the entire twenty-four programs, the average cost overrun in the EMD phase of the program was 45 percent and the average schedule overrun was 63 percent.

It was also possible to separate program cost success from program schedule success. Table 5 lists the number of success rankings at each success level for both cost and schedule. As shown, more programs were better able to control their cost overruns than their schedule overruns.

TABLE 5. Cost And Schedule Success Ratings

Program Success Rating	Cost Success Rating	Schedule Success Rating
5. Very Successful (V.S.)	10	1
4. Successful (S.)	4	8
3. Fairly Successful (F.S.)	3	4
2. Marginally Successful (M.S.)	1	2
1. Not Successful (N.S.)	6	9
	24	24

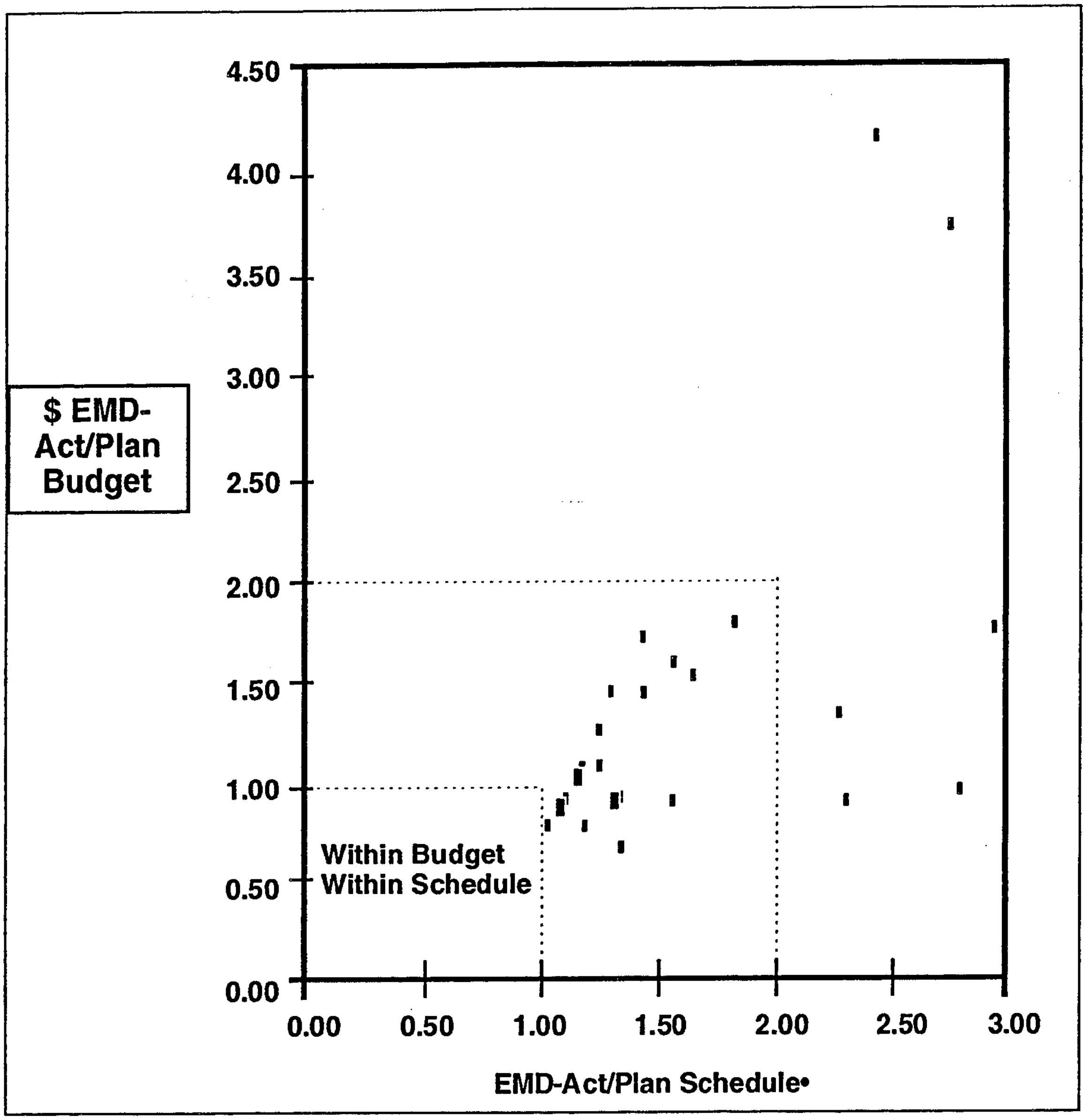

FIGURE 2. Actual vs. Planned Schedule and Budget

Low Rate Initial Production (LRIP)

Data and analysis relative to the prime objective of the study are shown in Figures 3, 4, and 5. Figure 3 is based upon a sample of twenty-one programs, since three programs had no Research, Development, Test and Evaluation (RDT&E) funded LRIP/Initial Production Articles. One program had procurement funded LRIP articles only, no RDT&E funded or full rate production articles. When the test quantity is over 3 percent of the total planned production quantity, the schedule slippage historically did not exceed 50 percent. Fifty percent was selected as the metric considering the average schedule overrun of the sample programs, (63 percent), and the number of programs that were considerably above this figure.

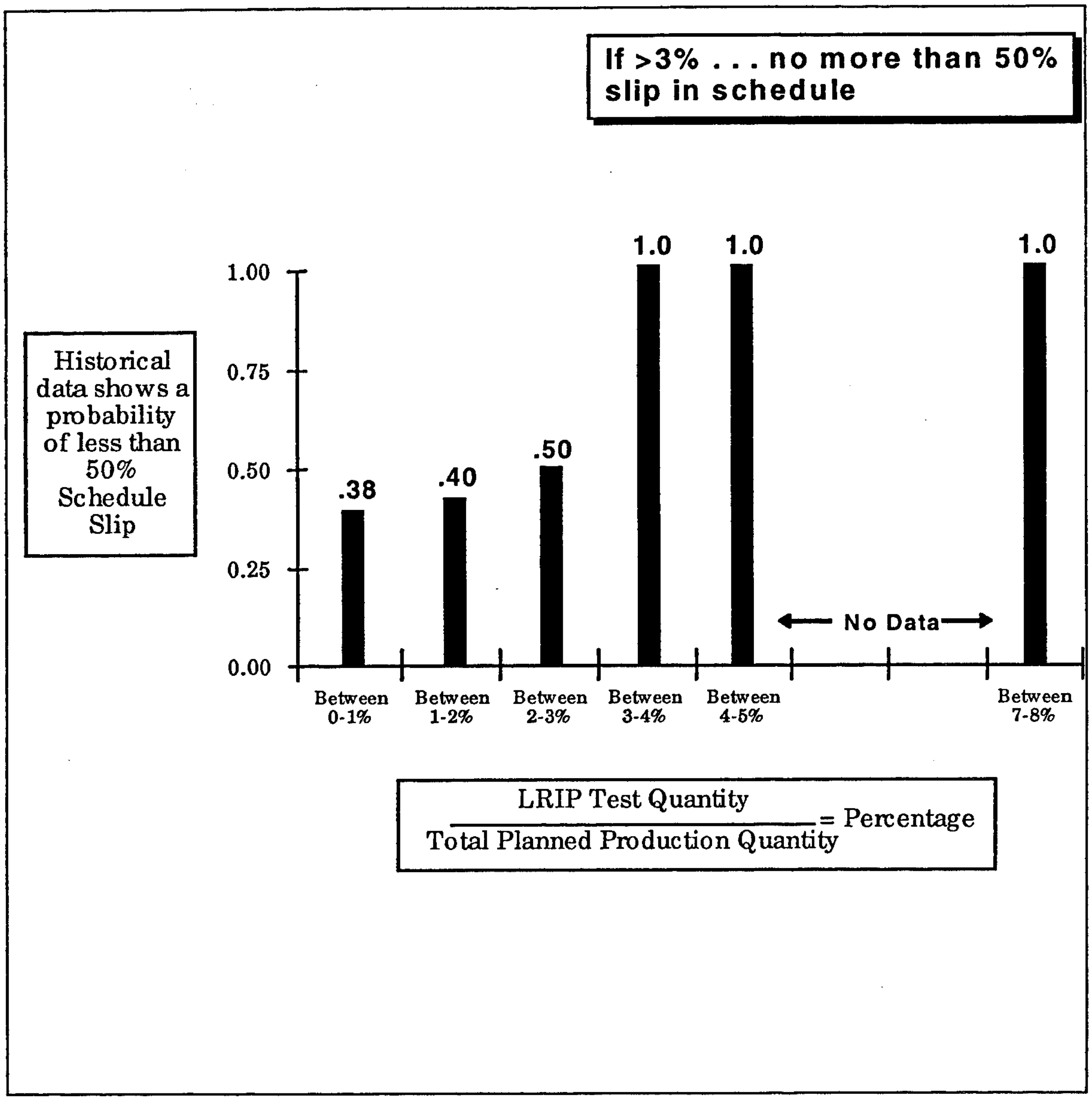

FIGURE 3. LRIP Test Articles and Schedule Slippage

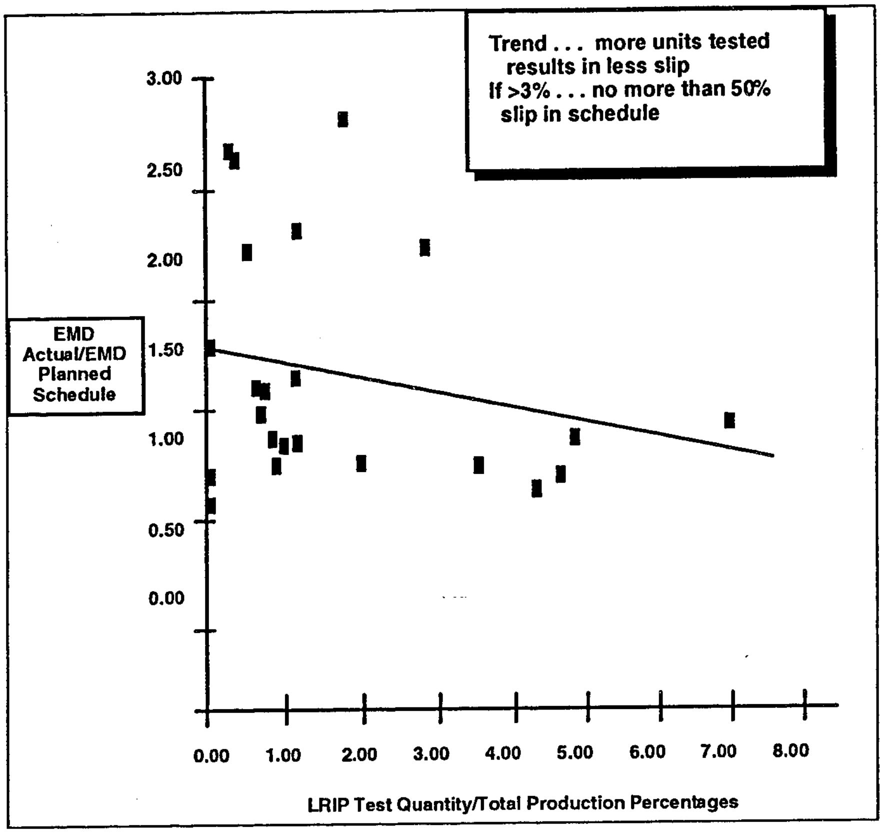

FIGURE 4. LRIP Test Quantity vs. EMD Schedule Slippage

For twenty-three programs, Figures 4 and 5 show a linear regression analysis when schedule, then cost overruns, were compared to the percentage of test articles used. As shown, there appears to be a mild negative correlation between the percent of RDT&E funded test articles compared with total production and cost/schedule overruns. Other derivative data obtained from the basic LRIP test articles vs. success database are discussed in Chapter 6.

Other Variables

The six other variables shown in Table 3 provided data amenable to graphical presentation in a standard format. From the data available in the program Blue Books or the Selected Acquisition Report (SAR), we assigned a success rating of one to five in accordance with the plan outlined previously. For example, did the program at Milestone (M/S) II indicate it was low risk or medium risk? Finally, we averaged the program success ratings of low risk programs and medium risk programs, and found in this instance, medium risk programs had a higher average program success rating than programs that were low risk.

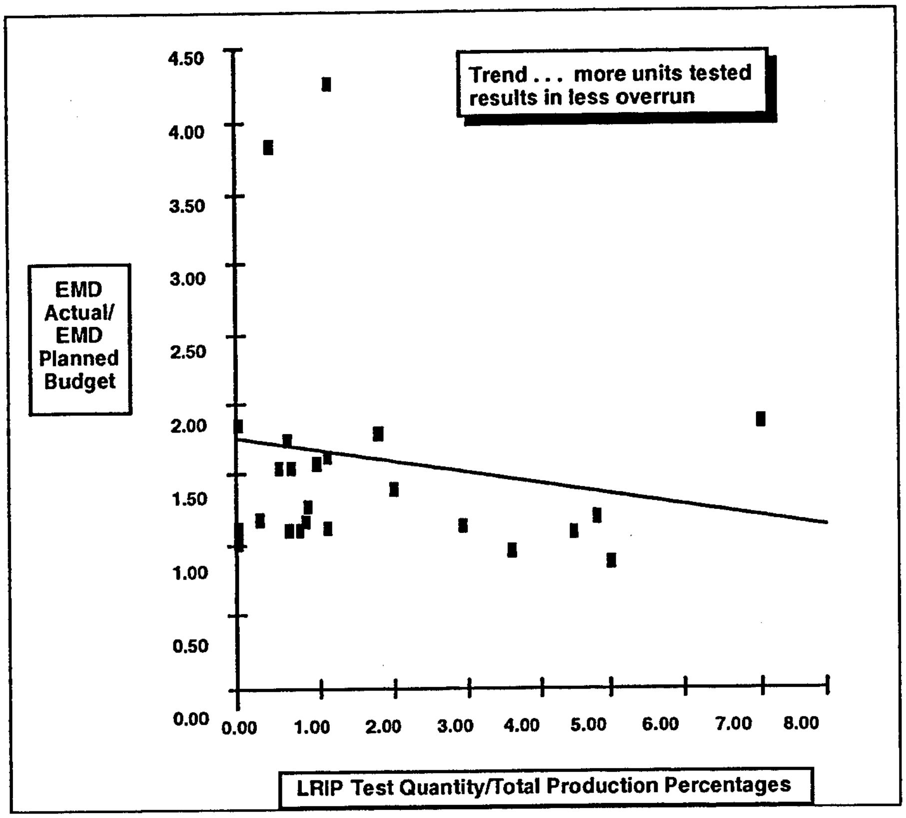

FIGURE 5. LRIP Test Quantity vs. EMD Budget Overrun

Initially we assumed a low risk program would have a better probability of success than a higher risk program. The data did not support this assumption. Programs that evaluated their risk as *low* at M/S II had an average success rating of 2.4 as compared to programs with a *medium* risk evaluation, that averaged a 3.3 success rating (see Figure 6). The asterisks shown within the figures are specific programs indicating the sample size and dispersion.

Whether or not a program used competition in the Demonstration/Validation (Dem/Val) phase, is shown in Figure 7. Those programs that used competition had a lower schedule success rating than programs that did not use competition. The same conclusion was reached for programs that used competition in the follow-on EMD phase, (see Figure 8).

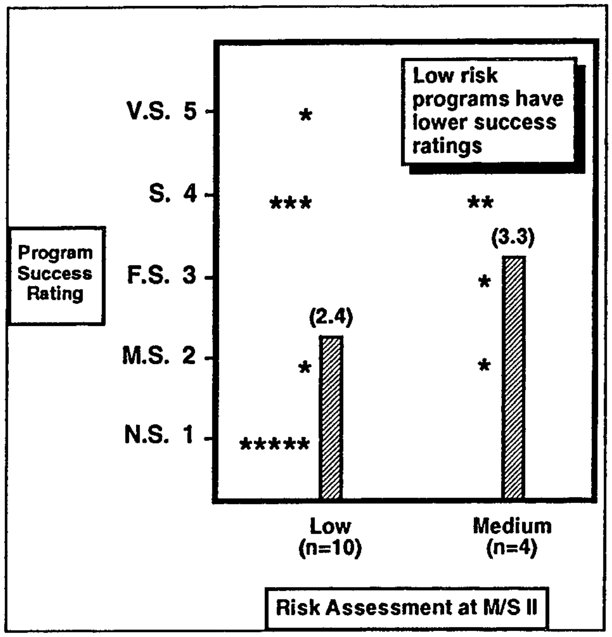

FIGURE 6. Risk Stated At M/S II

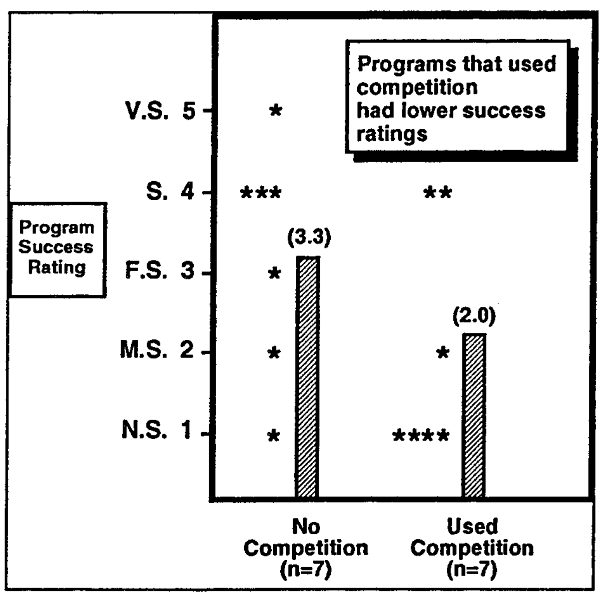

FIGURE 7. Competition in DEM/VAL

Four EMD contract types were evaluated and the data resulted in the following program success ratings: Cost Plus Incentive Fee, Fixed Price Incentive, and Firm Fixed Price all 3.3 and Cost Plus Award Fee 1.0 (see Figure 9). The data also showed that programs using one or no associate contractor (besides the Prime) had a success rating of 3.4 compared to a rating of 2.4 for the programs that used more than one associate contractor, as depicted in Figure 10. For probably the same organizational complexity reasons, single Service programs had an average success rating of 3.0 compared to Joint program's success rating of 1.8, seen in Figure 11. Additional comments regarding these findings are included in the next chapter.

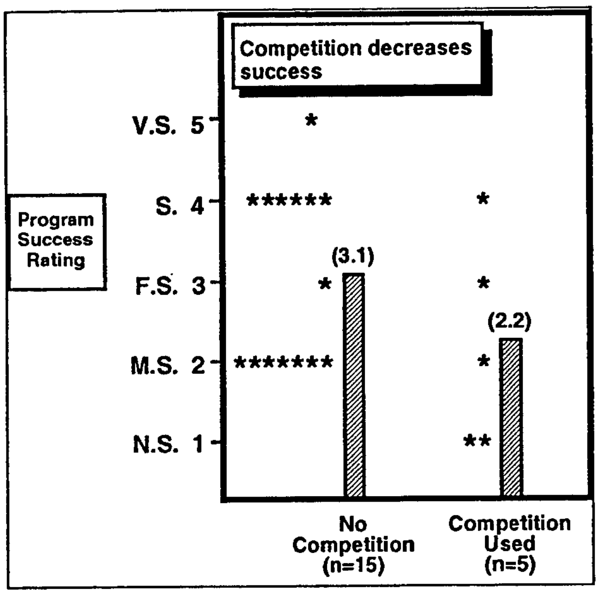

FIGURE 8. Competition in EMD

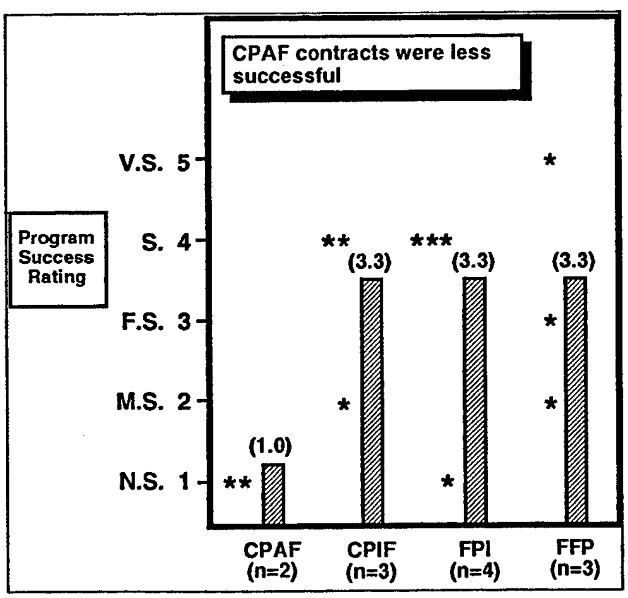

FIGURE 9. Type of Contract in EMD

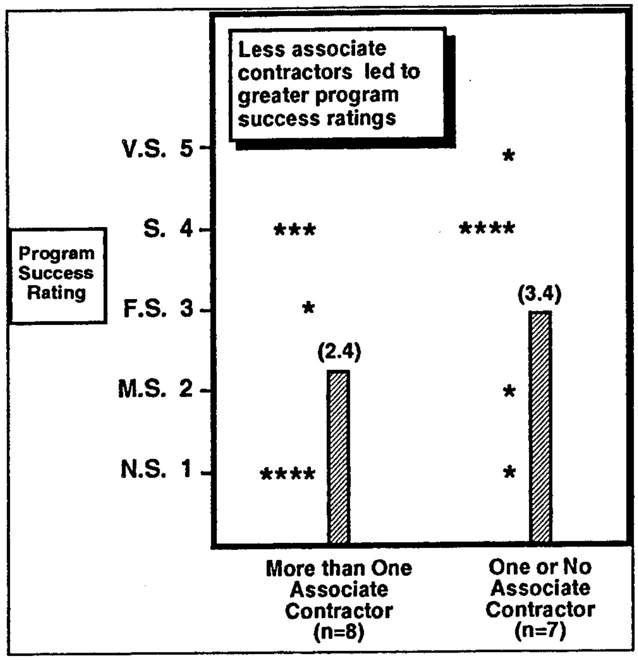

FIGURE 10. Number of Associate Contractors in EMD

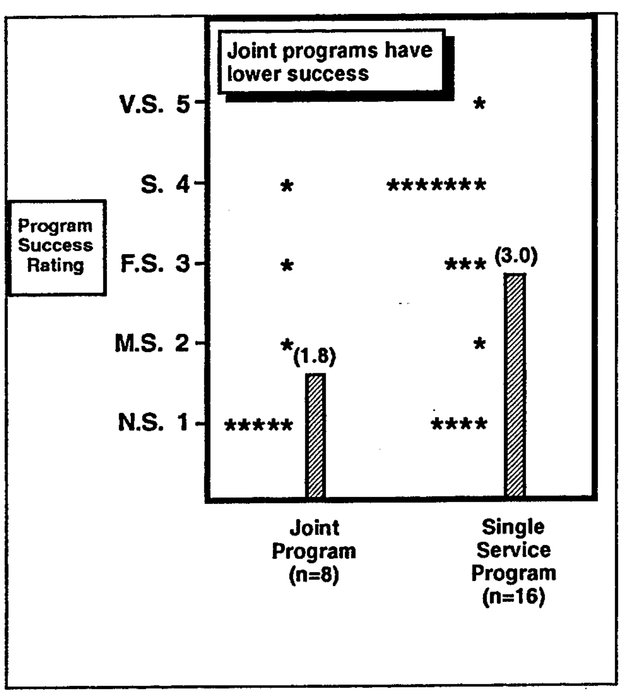

FIGURE 11. Joint Programs

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The research described in this report was sponsored by the Office of the Director of Operational Test and Evaluation, Office of the Secretary of Defense. The contents of this Technical Report do not necessarily reflect the opinions or policies of the sponsor.

General

The data presented herein were for twenty-four programs, except where otherwise noted. Figure 2 shows the cost schedule overruns for these programs, and Table 4 (finding number 7) shows the differences between the overruns for twenty-four programs and eighteen programs. This then, can be considered the Statistical Process Control limits on the current Department of Defense (DoD) Acquisition System.[22], and this thought is developed further in reference 22. The data for twenty-four programs also show an average Engineering and Manufacturing Development (EMD) phase of 7.4 years. For twenty-three programs, the average percentage of total Low Rate Initial Production (LRIP) articles compared to total planned production at Milestone (M/S) III, was 8.7 percent. Here fifteen programs had LRIP quantities below 8.7 percent, and eight program LRIP percentages were above the average. This latter data may be useful in studying program concurrency, a topic of interest these days. Recent Congressional action[23] requires at least one LRIP article for a major system, and seems to indicate LRIP quantities of up to 10 percent of the planned production quantity is acceptable without special concurrence.

More programs were better able to control their cost overruns than their schedule overruns. This is shown in Table 5. An assumption might be that if a program had a considerable schedule overrun, there would also be a considerable cost overrun, since "time is money." However, Figure 2 shows that of the six programs overrun by more than 100 percent, only two had comparable cost overruns. The database provided no factual information on why this occurred. An opinion as to why this occurred, is that schedule is a "law of physics" type of thing, where it takes so long to build a particular system with the performance specified in the specifications. Estimated cost on the other hand can be changed by several methods: de-scoping the program schedule of work, reducing the number of planned test articles, delaying logistical efforts until the production phase, etc., can probably be used to meet external or Service generated program cost caps.

The data also show that 28 percent of the total LRIP quantity was acquired with research, development, test and evaluation (RDT&E) funds and presumably used for testing. The remaining 72 percent was presumably used for other than test purposes. Proving out the manufacturing process and ramping up the production rate are the only other authorized purposes of LRIP systems. Since this is accomplished regardless of the LRIP systems end use, a question could be asked;

Is the current 28 percent LRIP test usage and 72 percent other than test usage, the proper mix of LRIP systems?

In this regard, as mentioned earlier (reference 12), a recent Naval Postgraduate School thesis concluded that the majority of the problems which occurred during Initial Operational Test and Evaluation/Operational Evaluation (IOT&E/OPEVAL) were directly related to test resource issues. It also recommended "sufficient test articles should be produced and available well before the operational test is supposed to start."

LRIP

Nuances of the LRIP process as used in DoD and the design of this research effort produce uncertainties that could affect the level of confidence associated with the LRIP vs. success results. Recall the primary determinant of the number of LRIP test articles used in the calculations was the number purchased with RDT&E funds, (see reference 21). This was compared to the total planned production estimated at M/S III, and the resultant percentage was used to compute the probability of less than a 50 percent schedule slip by the process previously described. Greater than three percent or more seemed to be the threshold of desired positive results.

However, the twenty-four systems varied from zero LRIP articles purchased with RDT&E funds to 464 articles. It also included total planned production quantities that varied from zero, (one program was canceled) through 287, to a maximum of 55,000. It depended entirely on the type of system, and in some cases very unique program circumstances. Therefore, it could be claimed that the metric, 3 percent or more, might be valid only over a mid-range of planned production. The database provided no factual information to refute or support this assumption. However, a review of the actual programs showed those using a low number of actual test articles were aircraft programs where a few test articles could be used for many tests, thereby being equivalent to a larger number of consumed test articles. Another group of programs using a low number of test articles were, unfortunately, electronic warfare and other programs that have generally been recognized as poor performers in EMD or canceled subsequently. On the high end of actual RDT&E funded test articles, there was one ground tactical positioning system, and two air launched tactical missiles. The ground system would require considerable test articles for a proper force on force, and end-to-end operational test, and the air launched missiles were consumed, thereby requiring more for robust Developmental Testing (DT) and Operational Testing (OT).

Another consideration is an outgrowth of additional guidance in the Comptroller's Regulation which states "Articles...which are not consumed in testing may be financed by procurement or Operation and Maintenance appropriations."[24] Therefore, systems whose test articles are consumed, such as tactical missiles, most probably were procured with RDT&E funds, and properly counted in the study. Systems like tactical radios, avionics, or even aircraft which could be used in testing and then returned to operational use, may have used some test articles procured with procurement funds. In this case, the number of

LRIP test articles procured with RDT&E funds, used in this study, would be augmented by additional quantities purchased with procurement funds.

The net result would be to unwittingly increase the number of test articles relative to total planned production, and move the system's percentage up, closer to the 3 percent mark, or even higher beyond that figure. Again, the database provided no factual information to refute or support this possibility. The study conclusion remains as originally stated, after consideration of the nuances discussed above, and ruminating on their possible effects.

Other Variables

The data contained within the database relative to risk estimation came as a surprise, considering the amount of effort put forth to indicate its importance. First, the data contradict a reasonable assumption that lower risk programs should have a higher probability of success. Second, the observed lack of much risk estimation data within the Blue Books, ostensibly an important part of the Defense Acquisition Board (DAB) process represents lack of discipline in the process. Other observations reached on the five other variables reviewed in this study stem directly from reduction of the data, and are considered self-explanatory.

Recommendations

The database shown in Appendix E should be made available to other researchers, preferably by electronic transmission.

This research should continue into Phase II where operational performance data, (effectiveness and suitability) would be added to the existing database. This could be accomplished by reviewing the DOT&E beyond LRIP reports, and/or the Service's Operational Test Agency's IOT&E Reports.

The existing database could be expanded. This could be accomplished by reviewing some of the other 41 programs originally considered, and/or by incorporating less than major systems. The former would result in reviewing programs somewhat older in time, and the latter group of programs may allow an interesting comparison between the data reviewed at a Service Program Decision Review Meeting, and an Office of the Secretary of Defense DAB meeting.

A correlation of the seven program variables covered here could be made, using multivariate analysis techniques to determine the relative importance of each variable. Additional research is required to provide factual data relative to the nuances of the LRIP process and the design of this study, discussed briefly above.

APPENDIX A
DEFINITIONS

ENGINEERING DEVELOPMENT MODEL - A weapon system that is an advanced prototype used during the post-MS II Engineering Manufacturing Development (EMD) phase to resolve design deficiencies, demonstrate maturing performance, and develop proposed production specifications and drawings. (Source: TE Department, DSMC)

INITIAL PRODUCTION ARTICLE - An initial production article is a program end item system that was produced in the Engineering and Manufacturing Development (EMD) phase primarily for proof of design and manufacturing process testing. The article may be called Low Rate Initial Production (LRIP), or production representative Engineering Development Model (EDM), Pre-Production (PP), Product Verification (PV), etc. Either RDT&E or Production funds can be used to procure the article. However, the degree to which the initial production article is production representative is important. (Source: R. W. Reig, DSMC)

LRIP TEST QUANTITY - The number of LRIP articles purchased with RDT&E funds, and presumably used for all system level testing in EMD. Column 16 of the database. (Source: R. W. Reig, DSMC)

PRODUCTION REPRESENTATIVE/PRODUCTION CONFIGURATION - A weapon system that can be used for Engineering and Manufacturing Development Phase (EMD) Initial Operational Test and Evaluation (IOT&E). It is a mature Engineering Development Model (formerly referred to as Pre-Production Prototype) or a Low Rate Initial Production (LRIP) end item in its final configuration, conforming to production specifications and drawings, and has demonstrated performance to appropriate maturity levels. System level Critical Design Review, qualification testing, and Functional Configuration Audit should have been completed with no significant deficiencies outstanding. (Source: TE Department, DSMC)

PROTOTYPE - An original or model on which a later item is formed or based. Usually built during concept DEM/VAL phase and tested prior to M/S II decision. (Source: Glossary, DSMC)

APPENDIX B
Study Population and Screening Criteria

	STUDY POPULATION AND SCREENING CRITERIA					
Study Population	Service	Joint	Weapon Type	BLRIP	SAR	Mod?
JTIDS (Class 2 terminals)	AF	X	Elec-CNR-A	no	yes	no
LANTIRN (Nav & Tgt)	AF		Elec-CNR-A	yes	yes	no
Navstar GPS/U.E.	AF	X	Elec-CNR-A	no	yes	no
OH-58D/AHIP	Army		Elec-CNR-A	yes	yes	no
CV HELO (SH-60F)	Navy		Elec-CNR-A	yes	yes	yes
E-6A (TACAMO II)	Navy		Elec-CNR-A	yes	yes	no
S-3B (WISP) Viking	Navy		Elec-CNR-A	yes	no	yes
MCS	Army		Elec-CNR-G	no	yes	no
MSE	Army		Elec-CNR-G	yes	yes	yes
SINCGARS	Army		Elec-CNR-G	yes	yes	no
Tac Army CSS Cptr Sys	Army		Elec-CNR-G	yes	yes	no
TTC-39 (TRI-TAC Switch)	Army	X	Elec-CNR-G	no	yes	no
SQS-53C SONAR	Navy		Elec-CNR-G	yes	no	
ALQ-184 Jammer	AF		Elec-EW-A	yes	no	
ALR-56M RWR	AF		Elec-EW-A	yes	no	
ASPJ (ALQ-165)	Navy	X	Elec-EW-A	yes	yes	no
ACM	AF		Mis/Mu-A	yes	yes	no
ALCM	AF	X	Mis/Mu-A	no	yes	no
AMRAAM	AF	X	Mis/Mu-A	yes	yes	no
ASAT (AF)	AF		Mis/Mu-A	no	yes	no
HARM	AF	X	Mis/Mu-A	no	yes	no
Maverick AGM-65D	AF		Mis/Mu-A	yes	yes	yes
Peacekeeper (MX)	AF		Mis/Mu-A	no	yes	no
Tomahawk (TASM & TLAM-C	Navy		Mis/Mu-A	yes	yes	yes
155mm HIP (Paladin)	Army		Mis/Mu-G	yes	yes	yes
ATACMS	Army		Mis/Mu-G	yes	yes	no
Avenger (Ped Mtd Stinger)	Army		Mis/Mu-G	yes	yes	no
FAADS LOS-F-H (ADATS)	Army		Mis/Mu-G	no	yes	no
SGT YORK gun (DIVAD)	Army		Mis/Mu-G	yes	yes	no
MK 48 ADCAP	Navy		Mis/Mu-G	yes	yes	yes
MK 50 Torpedo (ALWT)	Navy		Mis/Mu-G	no	yes	no
Trident II msl (D-5)	Navy		Mis/Mu-G	no	yes	no
VLA (UUM-139 ASROC)	Navy		Mis/Mu-G	yes	no	
B-1B Lancer (ALQ-161)	AF		Aicraft	no	yes	yes
AV-8B (Harrier II)	Navy		Aircraft	yes	yes	yes
MH-53E Sea Dragon	Navy		Helo	yes	yes	no
M-1A1 Abrams	Army		Vehicle	yes	yes	yes
M9 ACE (UET)	Army		Vehicle	yes	no	no
M939A2 Truck (MTV)	Army		Vehicle	yes		yes
PLS (FHTV)	Army		Vehicle	yes	yes	no
LAV(N)	Navy		Vehicle	no	yes	no

APPENDIX B (CONT)

Screening Criteria

The study sample selected from the population was subjected to the following screening.

- All services and some joint programs will be considered.

- Similar programs between services will be considered for comparisons.

- Similar programs which used dissimilar initial production approaches will be considered.

- Programs associated with equipment used by all Services will be considered. Ship hulls and military satellites will not be included.

- Programs must have completed M/S II before 12/90.

- Programs must have completed M/S III, (completed EMD).

- Programs with first operational delivery before 1/81 will not be included. (Too old)

- Programs terminated, in progress or concluded can be considered.

- Availability of program data will be an important consideration.

- All programs which received BLRIP reports, except satellite/ship programs.

APPENDIX C
INITIAL LIST OF OTHER VARIABLES AFFECTING PROGRAM SUCCESS

A. Degree of Program Concurrency (Overlap of Development and Production Efforts).

- Degree of technical difficulty identified at M/S II
    - Modification vs. New Development, ORD requirements vs. current system capabilities, (State of the Art)

- Degree of software intensive development
    - Total system lines of code

- Program schedule vs. a nominal schedule
    - Months planned for EMD

- Degree the LRIP articles are production representative

    - Number of Waivers requested on Certification of Readiness for IOT&E or number of ECP's

- Use of competition during Dem/Val phase

B. Complexity of business, management arrangements.

- Type of contract

- Number of associate contractors

- Joint program

- Use of competition during EMD phase

C. Instability of Funding and Planning.

- Initial Production Article phases

    - Number originally planned vs. number actually used

- Joint program with withdrawal of one Service

D. Prior use of Prototypes as discussed in RAND Report.

- Used or not used

APPENDIX D
PROGRAM SCHEDULE AND COST SUCCESS

Program	Schedule Success Rating (months overrun)	Cost Success Rating (% dollar overrun)
1. CV Helo	5	5
2. MK 48	4	5
3. Avenger	4	5
4. ACM	4	4
5. OH-58D	4	4
6. Trident	4	5
7. AV-8B	4	4
8. ASAT	3	4
9. ALCM	4	3
10. GPS/U.E.	1	5
11. LANTIRN	3	5
12. ATACMS	4	5
13. Tri-Tac	2	1
14. HARM	3	3
15. PLS	3	5
16. Sgt. York	2	1
17. MK 50	1	2
18. FAADS	1	1
19. AMRAAM	1	3
20. B1B	1	5
21. JTIDS	1	1
22. ASPJ	1	1
23. Maverick	1	5
24. Tomahawk	1	1

APPENDIX E
Database Descriptions

Column	Description
0	Study Population (Sample), 24 programs.
1	The actual date the program M/S II DAB meeting was held.
2	The planned date, (at M/S II) for the program M/S III DAB meeting.
3	The actual date the program M/S III DAB meeting was held.
4	The planned duration of phase II, (EMD), in years.
5	The actual duration of phase II, (EMD), in years.
6	The ratio of actual duration of EMD, to the planned duration (Col 5 divided by Col 4).
7	The cost of EMD as estimated at the M/S II DAB meeting.
8	The FY dollars in which the Col 7 figure is expressed. When the Col 8 FY is different than the FY in which the M/S II DAB meeting was held, the cost figure in Col 7 has been adjusted for inflation so that Column 7 and Column 8 are expressed in the same FY dollars.
9	The actual cost of EMD as reported at the M/S III DAB meeting.
10	The ratio of the actual cost of EMD to the planned cost of cost. (Col 9 divided by Col 7).
11	The program budget success rating assigned to the program in accordance with (iaw) Table 2.
12	The actual percentage the program overran the planned EMD budget.
13	The program schedule success rating assigned to the program IAW Table 2.

Column	Description
14	The actual percentage the program overran the planned EMD schedule. (6 minus 1) x100.
15	The actual months the program overran the planned EMD schedule.
16	The number of LRIP systems, identified by several names, (see Appendix A for definition), purchased in EMD with RDT&E funds presumably used for testing, i.e., test articles.
17	The number of LRIP systems, identified by several names purchased in EMD with production funds, and presumably used for other than test purposes.
18	The total LRIP systems purchased in EMD. (Col 16 plus Col 17).
19	The total planned production quantity as estimated at M/S III.
20	The percentage of test articles when compared to total planned production. (Col 16 divided by Col 19) x 100.
21	The ratio of RDT&E funded articles to total EMD articles (Col 16 divided by Col 18).
22	The percentage of total LRIP systems purchased in EMD when compared to total planned production. (Col 18 divided by Col 19).
23	Taxonomy of weapon system types. (see Database Description).
24	The DoD component, or lead service developing the system.
25	X Indicates whether the system is being developed as a Multi-Service program.
26	Yes indicates that the DOT&E issued a "Beyond LRIP" report to Sec Def, Congress, and the M/S III DAB meeting on the date shown in Col 3.

Column	Description
27	Yes indicates the program was on the list of DOD SAR systems.
28	Indicates whether the program is a major modification, or a new development in the EMD phase.
29	Indicates whether the DAB Blue Books recorded the number of Software Lines of Code associated with the program, as a metric of program risk.
30	The Program Manager's estimate of technical risk as stated at M/S II.
31	A research study number assigned to the program technical risk (see Col 29).
32	Indicates whether the program used prime contractor competition in the Dem/Val phase of the program.
33	Indicates whether the program used prime contractor competition in the EMD phase of the program.
34	Indicates the type of contract used in the EMD phase. (FFP=Firm Fixed Price, CPIF=Cost Plus Incentive Fee, FPI=Fixed Price Incentive, CPAF=Cost Plus Award Fee).
35	Number of Associate Contractors used at the prime system level, i.e., WBS level II.
36	The actual date of the program's M/S I DAB meeting.
37	The planned date of the program M/S II DAB meeting.
38	The ratio of the actual duration of Dem/Val to the planned duration. $\frac{(1 \text{ minus } 35)}{(36 \text{ minus } 35)}$
39	The actual date of the M/S III A DAB meeting. This M/S meeting is no longer used, but in the past typically signified the start of the LRIP phase within the EMD program phase.

Column	Description
40	The planned date of the start of the IOT&E/OPEVAL test.
41	The actual date of the start of the IOT&E/OPEVAL test.
42	The planned date to conclude the IOT&E/OPEVAL test.
43	The actual date the IOT&E/OPEVAL test ended.
44	The ratio of the duration of the IOT&E/OPEVAL test to the planned duration. (Cols 40 and 42 time interval divided by Cols 39 and 41 time interval).
45	The planned date of the Operational Delivery of the system, generally the Initial Operational Capability (IOC) date. (Only entered if unclassified)
46	The actual date of the Operational Delivery of the system.
47	The number of months difference between the actual and planned dates of the system's Operational Delivery.

Data Base - - 24 Programs

	1	2	3	4	5	6	7
Study Population	MS II(actual)	MS III(plan)	MS III(actual)	phase II plan	phase II actual	EMD-act/plan	$(MS III plan)
CV HELO (SH-60F)	Mar-85	Mar-88	Mar-88	3.00	3.00	1.00	60.00
MK 48 ADCAP	Sep-82	Aug-88	Jan-89	5.91	6.39	1.08	1312.00
Avenger (Ped Mtd Stinger)	Mar-86	Dec-89	Apr-90	3.75	4.11	1.10	13.00
ACM	Apr-83	Jun-90	Jul-91	7.16	8.25	1.15	1417.00
OH-58D/AHIP	Apr-82	Apr-85	Oct-85	3.00	3.50	1.17	210.00
Trident II msl (D-5)	Oct-83	Sep-86	Mar-87	2.91	3.41	1.17	9145.00
AV-8B (Harrier II)	Jul-79	Apr-84	Apr-85	4.75	5.75	1.21	873.00
ASAT (AF)	Feb-80	Sep-86	Mar-88	6.58	8.08	1.23	852.00
ALCM	Jan-77	Aug-79	Apr-80	2.57	3.28	1.28	546.00
Navstar GPS/U.E.	Jul-79	Mar-89	Jan-92	9.67	12.56	1.30	942.00
LANTIRN (Nav & Tgt)	Dec-79	Feb-85	Oct-86	5.17	6.83	1.32	403.00
ATACMS	Feb-86	Sep-89	Nov-90	3.53	4.70	1.33	758.00
TTC-39 (TRI-TAC Switch)	Apr-74	Sep-78	Jul-80	4.39	6.24	1.42	105.00
HARM	Feb-78	Sep-81	Mar-83	3.58	5.16	1.44	227.00
PLS (FHTV) (NDI)	May-88	Apr-91	Nov-92	2.86	4.44	1.55	38.00
SGT YORK gun (DIVAD)	Oct-77	Sep-80	May-82	2.92	4.58	1.57	163.00
MK 50 Torpedo (ALWT)	Jan-84	Oct-88	Sep-91	4.70	7.61	1.62	744.00
FAADS LOS-F-H (ADATS)	Nov-86	Apr-90	Dec-92	3.41	6.08	1.78	297.00
AMRAAM	Sep-82	Dec-86	Apr-92	4.25	9.64	2.27	584.00
B-1B Lancer (ALQ-161)	Mar-82	Nov-86	Dec-92	4.67	10.75	2.30	2942.00
JTIDS (Class 2 terminals)	Jan-81	Jun-86	Oct-93	5.38	12.72	2.36	309.00
ASPJ (ALQ-165)	Jul-79	Jul-84	Dec-92	4.96	13.37	2.70	139.00
Maverick AGM-65D (IIR)	Sep-76	Mar-80	Mar-86	3.43	9.43	2.75	100.00
Tomahawk (TASM & TLAM-C)	Jan-77	Sep-80	Sep-87	3.65	10.65	2.92	783.00

3/9/95

8	9	10	11	12	13	14	15	16	17	18
FY	$(MS III actual	$EMD-act/plan	$ Suc	$%	Time Suc	Time %	Time Mos	EMD Prod-R	EMD Prod-P	Tot EMD Prod
85	54	0.90	5	-10	5	0	0	0	7	7
89	1285	0.98	5	-2	4	8	6	48	151	199
89	13	1.00	5	0	4	10	4	0	134	134
83	1556	1.10	4	10	4	15	13	25	40	65
82	237	1.13	4	13	4	17	6	5	16	21
84	7901	0.86	5	-14	4	17	6	30	21	51
79	1113	1.27	4	27	4	21	12	6	48	54
77	973	1.14	4	14	3	23	18		11	11
77	789	1.45	3	45	4	28	9	24	48	72
79	937	0.99	5	-1	1	30	35	464	2148	2612
80	404	1.00	5	0	3	32	20	6		6
91	562	0.74	5	-26	4	33	14	50	170	220
74	180	1.71	1	71	2	42	22	9	0	9
78	325	1.43	3	43	3	44	19	99	316	415
88	37	0.97	5	-3	3	56	19	27	762	789
78	267	1.64	1	64	2	57	20	4	20	24
89	1137	1.53	2	53	1	62	35	90	416	506
89	526	1.77	1	77	1	78	32		14	14
78	824	1.41	3	41	1	127	65	128	4545	4673
81	3052	1.04	5	4	1	130	73	3		3
81	1296	4.19	1	319	1	136	88	20	164	184
79	522	3.76	1	276	1	170	101	12	111	123
75	107	1.07	5	7	1	175	72	70	1100	1170
77	1316	1.68	1	68	1	192	84	74	168	242

19	20	21	22	23	24	25	26	27	28	29
Tot Prod	EMD R/Tot Pr	EMD R/Tot EMD	EMD/Tot Prod	Weapon Type	Service	Joint	BLRIP	SAR	Mod?	S/W LOC
175	0.00%	0.00%	4.00%	Elec-CNR-A	Navy		yes	yes	yes	
1062	4.52%	24.12%	18.74%	Mis/Mu-G	Navy		yes	yes	yes	
950	0.00%	0.00%	14.11%	Mis/Mu-G	Army		yes	yes	no	
520	4.81%	38.46%	12.50%	Mis/Mu-A	AF		yes	yes	no	
578	0.87%	23.81%	3.63%	Elec-CNR-A	Army		yes	yes	no	
815	3.68%	58.82%	6.26%	Mis/Mu-G	Navy		no	yes	no	
287	2.09%	11.11%	18.82%	Aircraft	Navy		yes	yes	yes	
				Mis/Mu-A	AF		no	yes	no	
2328	1.03%	33.33%	3.09%	Mis/Mu-A	AF	X	no	yes	no	
55000	0.84%	17.76%	4.75%	Elec-CNR-A	AF	X	no	yes	no	
500	1.20%	100.00%	1.20%	Elec-CNR-A	AF		yes	yes	no	
1000	5.00%	22.73%	22.00%	Mis/Mu-G	Army		yes	yes	no	
126	7.14%	100.00%	7.14%	Elec-CNR-G	Army	X	no	yes	no	
13754	0.72%	23.86%	3.02%	Mis/Mu-A	AF	X	no	yes	no	
3500	0.77%	3.42%	22.54%	Vehicle	Army		yes	yes	no	
618	0.65%	16.67%	3.88%	Mis/Mu-G	Army		yes	yes	no	
7700	1.17%	17.79%	6.57%	Mis/Mu-G	Navy		no	yes	no	
6800	0.00%	0.00%	0.21%	Mis/Mu-G	Army		no	yes	no	
24000	0.53%	2.74%	19.47%	Mis/Mu-A	AF	X	yes	yes	no	56K
100	3.00%	100.00%	3.00%	Elec-EW-A	AF		no	yes	yes	
1700	1.18%	10.87%	10.82%	Elec-CNR-A	AF	X	no	yes	no	
3200	0.38%	9.76%	3.84%	Elec-EW-A	Navy	X	yes	yes	no	
25000	0.28%	5.98%	4.68%	Mis/Mu-A	AF		yes	yes	yes	
3994	1.85%	30.58%	6.06%	Mis/Mu-A	Navy		yes	yes	yes	

30	31	32	33	34	35	36	37	38	39
Tech Risk	Tech Risk#	D/V Comp	EMD Comp	EMD K	Subs	MS I(actual)	MS II(plan)	phase 1 act/pln	MS IIIa(actual)
Low	1	No	No	FFP	1	Jun-87	Jan-89	-1.42	Mar-92
	0		No	CPIF	2	Sep-79		-0.04	Sep-85
	0								Aug-87
	0	Yes	No		2	Nov-82	Apr-83	1.00	Jul-86
Low	1	No	No	FPI	1	Jul-80	Sep-81	1.50	Sep-84
Low	1	No	No	CPIF	1	Oct-80	Oct-83	1.00	Apr-90
Med	2	No	No		1	Mar-76			Sep-83
	0					Sep-79	Jun-84	0.09	
Mod	2	Yes	Yes	FPIF	2	Feb-78	Jan-81	-0.37	Apr-84
Low	1	Yes	Yes			Dec-77	Jun-83	0.29	Jun-90
	0								Mar-89
Low	1	Yes	No	FPI	1	May-85	Dec-85	1.37	Feb-89
Low	1	Yes	No	CPIF	1	Sep-76	May-80	-0.65	Nov-85
Med	2	No	No			Oct-72	Feb-78	1.00	
	0	No	Yes	FFP	3		Jan-79	1.13	May-83
Med	2	No	Yes	FFP	Yes	Oct-78	Jun-80	-0.60	Oct-82
Low	1	Yes	No	CPAF	2	Jul-79	Apr-83	1.21	Mar-89
	0	Yes	No		1	Jan-86	Nov-87	0.45	Jun-90
Low	1	Yes	No	FPIF	2	Nov-78	Nov-82	0.96	Jun-87
	0						Mar-82	1.00	Jan-86
	0		No		2	Mar-80	Jan-85	0.18	Jan-90
Low	1	Yes	No	CSAF	2	Mar-76			Jun-89
Low	1	No	No		1	Nov-77	Sep-80	-0.39	Mar-86
	0	Yes	Yes			Feb-74	Jan-77	1.00	Dec-84

40	41	42	43	44	45	46	47
IOTE Start(pla	IOTE Start(actu	IOTE End(plan)	IOTE End(actu	IOTE tm ac/pl	Op Del(plan)	Op Del(actual)	Op Del ac-pl
Nov-91	Nov-87	Dec-91	Jan-88	2.00		Jul-91	6
	Oct-87	Apr-88	May-88		Sep-88	Aug-88	
		May-90	Aug-90	1.00			0
Jul-84	Jan-84	Jan-85	Dec-84	1.84	Jun-86	Feb-86	
					Nov-89	Mar-90	-8
Oct-83	Sep-84	Dec-83	Mar-85	2.97	Jun-85	Aug-85	2
Jan-88	Jan-88				Apr-91		-3
Jan-80	Apr-80	Dec-80	Feb-84	4.20	Dec-82	Nov-85	
Jan-87	Jun-93	Aug-87			Apr-89	May-91	1
Jul-87	Dec-92	May-92			Jul-86	Jun-92	
Feb-90	Mar-90	May-90	Jun-90	1.00	Oct-90	Dec-90	2
Oct-79		Jun-80			Apr-84	Jan-83	
Dec-80	Nov-81	Jul-81	Nov-82	1.71	Sep-81	Nov-83	2
Jul-81	Nov-81	Sep-81	Nov-83	12.00		Aug-93	7
Jan-84	Dec-89	Jun-90	May-90	0.06	Sep-90	Aug-90	-1
Dec-89		Sep-90				Jul-91	6
Mar-98		Nov-98			Sep-97		-8
Oct-87		Apr-93			Aug-86	Mar-91	
Oct-84	Mar-87	Jun-90			Dec-88	Oct-86	-2
Jul-87	Jun-88	Jan-90	Apr-91	1.13	Jul-87	Jun-88	
Jan-84	Jun-88	Sep-86	Jul-92	1.53	Dec-86		-11
Nov-82	Jun-84	Jan-84	Aug-86	1.86		Oct-87	9
Nov-79	Feb-83	May-80	Oct-83	1.33	Jun-81	Nov-83	

ENDNOTES

[1] The U.S. Navy and U.S. Marine Corps call this specific phase of Operational Testing (OT), Operational Evaluation (OPEVAL). In prior years the Office of the Secretary of Defense (OSD) called this particular test the ""final dedicated phase of operational testing prior to Milestone (M/S) III."

[2] United States Code, Title 10, Section 2399.

[3] Conversations between Dr. E. Seglie, Science Advisor to the Director of Operational Test and Evaluation (DOT&E) and Professor R. Reig, Defense Systems Management College (DSMC).

[4] United States Code, Title 10, Section 2400.

[5] Research on Ongoing Acquisition Research (ROAR) is a service for subscribers inside and outside government who are CURRENTLY conducting research projects dealing with vital defense acquisition issues.

[6] The industry field trip is a portion of the DSMC Program Management Course. For one week students visit a company that is currently producing a major system. As part of the exercise, the company forwards to DSMC extensive program data similar to that provided to DoD.

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[19] Some program Blue Books and SAR's used constant dollar figures adjusted to the M/S II FY dollars. Other programs documented their costs in both constant and then year dollars. Where time adjusted cost data was not available, the OMB, CPI inflation index was used.

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